CS-059-70097-2

FINAL

DECISION DOCUMENT

FORMER SCHILLING ATLAS F MISSILE SITE S-5
MCPHERSON COUNTY, KANSAS

FUDS PROJECT NO. B07KS026301

July 2012

US Army Corps
of Engineers®

U.S. ARMY CORPS OF ENGINEERS
Kansas City District
Kansas City, MO

DEPARTMENT OF THE ARMY
KANSAS CITY DISTRICT, CORPS OF ENGINEERS
700 FEDERAL BUILDING
KANSAS CITY, MISSOURI 64106-2896

REPLY TO
ATTENTION OF

Environmental Program Branch

RECEIVED

OCT 15 2012

BUREAU OF
ENVIRONMENTAL REMEDIATION

October 12, 2012

Ms. Jamie Schwartz
Project Manager
Bureau of Environmental Remediation, Superfund Unit
Kansas Department of Health & Environment
1000 SW Jackson Street
Topeka, KS 66612

Dear Ms. Schwartz:

Enclosed for your records please find a copy Final Decision Document (DD) for the former Schilling Atlas Missile Site S-5 near McPherson Kansas. Should you have any questions, please contact me at (816) 983-3239 or email me at saqib.khan@nwk02.usace.army.mil.

Sincerely,

M Saqib

Mohammad Saqib Khan, P.G.
Project Manager

cc: Paul Roemerman, EPA Region VII

Enclosures

DECISION DOCUMENT

FORMER SCHILLING ATLAS F MISSILE SITE S-5
MCPHERSON COUNTY, KANSAS

FUDS PROJECT NO. B07KS026301

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Kansas City, MO

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EXECUTIVE SUMMARY FOR HQDA

Former Schilling Atlas F Missile Site S-5
McPherson County, Kansas
FUDS Project Number B07KS026301

Decision Document
Signed by: Dr. Christine T. Altendorf
September 6, 2012

This Decision Document (DD) presents the Selected Remedy for remediation of groundwater at the Former Schilling Atlas F Missile Site S-5. The remedy was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This Selected Remedy decision is based on the Administrative Record file for this site concurred with by the Kansas Department of Health and Environment (KDHE).

The U.S. Army Corps of Engineers (USACE) has been conducting environmental investigations and restoration activities at the Former Schilling Atlas F Missile Site S-5 since 1988. The former landowner originally obtained all potable water from a water supply well located west-southwest of the silo. However, due to the discovery of trichloroethene (TCE) contamination in this domestic water supply well, a series of interim measures were performed by USACE at the Site in order to provide the landowner with potable drinking water. In 1991, USACE began providing bottled water to the landowner. In 1993, USACE installed a granular activated carbon (GAC) water treatment system as an interim solution to provide the landowner with a potable water supply. In 2001, a new rural water district was created by local citizens with service to area landowners. In the fall of 2003, USACE had the landowner's residence connected to the Lindsborg Area Rural Water District and discontinued use of the GAC water treatment system. This response action mitigated the immediate risk potential for ingestion of, and dermal exposure to, concentrations of chemicals of concern (COCs) in groundwater.

The five alternatives considered for groundwater remediation include: No Action; Long-Term Monitoring (LTM); Enhanced Anaerobic Bioremediation (EAB) with MNA; Permeable Reactive Barrier (PRB) or Biowall with MNA; and in-situ chemical oxidation (ISCO) with MNA. The four remedial soil measures considered to minimize any impacts to groundwater from soil: No Action; SVE; Excavation; and ISCO Treatment. The Selected Remedy focuses on in-situ treatment of groundwater on the former missile base property. Soil Vapor Extraction (SVE) has been incorporated into the remedy to minimize the potential for impacts to the groundwater. Groundwater treatment will be followed by monitored natural attenuation (MNA) to monitor contaminant migration and remedy effectiveness. It is estimated that the groundwater remediation goals will be reached in approximately 78 years. Five-year reviews will be required until remediation goals are achieved.

Remedy costs are presented in the DD as both present worth and net-present worth. Net-present worth was used in the comparative analysis and evaluation of the remedies under the cost criteria. The Cost to Complete, present worth, was used for the purpose of determining signature authority. The present worth estimate of $9,806,700 ($7,054,500 plus $2,752,200) includes the current Cost to Complete as reflected in the Formerly Used Defense Sites Management Information System for fiscal 2013 to remedy completion ($7,054,500: includes $132,800 for RA-C and $6,921,700 for RA-O) and costs associated with remedy construction and operation that were obligated on a task order using a performance based acquisition strategy ($2,752,200: includes $2,633,800 for RA-C, and $118,400 for RA-O).

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List of Abbreviations and Acronyms

ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cis-1,2-DCE	*cis*-1,2-dichloroethene
COC	contaminant of concern
COPC	chemicals of potential concern
DD	decision document
DOD	Department of Defense
EAB	enhanced anaerobic bioremediation
FFID	Federal Facilities Identification
FUDS	Formerly-Used Defense Site
FS	feasibility study
GAC	granular activated carbon
GMW	groundwater monitoring well
GSR	green and sustainable remediation
HI	hazard index
ICBM	intercontinental ballistic missile
ISCO	in-situ chemical oxidation
KDHE	Kansas Department of Health and the Environment
LCC	launch control center
LTM	long-term monitoring
MCL	maximum contaminant level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
NCP	National Oil and Hazardous Substances Contingency Plan
PRB	permeable reactive barrier
RAO	remedial action objective
RG	remediation goal
RI	remedial investigation
ROI	radius of influence
Site	Former Schilling Atlas F Missile Site S-5
SVE	soil vapor extraction
TCE	trichloroethene
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
ZVI	zero-valent iron

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1.0 DECLARATION

1.1 Site Name and Location

Site Name: Former Schilling Atlas F Missile Site S-5
Location: McPherson County, Kansas
Formerly Used Defense Site (FUDS) Project Number: B07KS026301
Federal Facility Identification (FFID): KS9799F0307

1.2 Statement of Basis and Purpose

This Decision Document (DD) presents the selected remedy for the Former Schilling Atlas F Missile Site S-5 (Site), McPherson County, Kansas. The selected remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended by the Superfund Amendments and Reauthorization Act and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This decision is based on the Administrative Record for this site. The Kansas Department of Health and Environment (KDHE) concurs with the Selected Remedy.

1.3 Assessment of the Site

Releases of contaminants from this site, if not addressed by implementing the response action selected in this DD, may present a current or potential threat to human health, welfare, or the environment.

1.4 Description of the Selected Remedy

The selected remedy addresses groundwater contamination using an in-situ treatment technology and includes soil vapor extraction (SVE) to minimize the potential for impacts to groundwater. These actions are followed by monitored natural attenuation (MNA).

The selected remedy will include providing an alternate water supply to area residents if the drinking water supply becomes impacted by the Site-related contaminants of concern (COCs) above the Maximum Contaminant Levels (MCLs) in the future. An alternate water supply may consist of a provision of bottled water, granular activated carbon (GAC) treatment, or connection to a rural water district. A time critical removal action in 2003 connected the onsite resident to an alternate water supply.

Major components of the selected remedy include the following:

- In-situ treatment of groundwater to reduce contaminant concentrations in groundwater based on remedial design criteria focusing on areas of highest COC concentrations.
- Installation and operation of a SVE system in the soil area located near the launch control center (LCC) entrance on the missile base property.
- Installation of groundwater monitoring wells, sampling, and data analysis.

1.5 Statutory Determinations

The selected remedy is protective of human health and the environment, complies with federal and state laws and regulations that are applicable or relevant and appropriate to the remedial action, and is cost effective. This remedial action utilizes permanent solutions and alternative treatment technologies to the extent practicable. This remedy also satisfies the statutory preference for treatment as a principal element of the remedy. A five-year review will be conducted as appropriate to ensure remedy protectiveness to human health and the environment in accordance with CERCLA Section 121.

1.6 Data Certification Checklist

The following information is included in the Section 2, Decision Summary:

- COCs and their respective concentrations
- Baseline risk represented by the COCs
- Source materials (if any) constituting principal threats and how they will be addressed
- Current and reasonably anticipated future land uses, and current hypothetical future beneficial uses of groundwater, assessed in the baseline risk assessment
- Estimated capital costs, annual operation and maintenance costs, and total present worth; and the number of years over which the remedy cost estimates are projected
- Key factors that led to remedy selection

1.7 Approval

The United States Army Corps of Engineers (USACE) Headquarters denotes acceptance of this DD as the final response action for the entire site by signing the authorizing signature pages at the end of this section.

FINAL DECISION DOCUMENT

FORMER SCHILLING ATLAS F MISSILE SITE S-5
MCPHERSON COUNTY, KANSAS

APPROVAL

This Decision Document presents the selected remedy for the Former Schilling Atlas F Missile Site S-5, McPherson County, Kansas. The U.S. Army Corps of Engineers is the lead agency under the Defense Environmental Restoration Program (DERP) at the Former Schilling Atlas F Missile Site S-5 Formerly Used Defense Sites (FUDS) and has developed this Decision Document consistent with CERCLA, as amended, and the NCP. This Decision Document will be incorporated into the larger Administrative Record file for the Former Schilling Atlas F Missile Site S-5, which is available for public view at Miller Library, McPherson College, 1600 East Euclid, McPherson, KS 67460. This document, presenting a selected remedy with a total cost to complete (CTC) estimate of $9,806,700, is approved by the undersigned, pursuant to Memorandum, DAIM-ZA, September 9, 2003, Subject: Policies for Staffing and Approving Decision Documents, and to Engineer Regulation 200-3-1, FUDS Program Policy.

APPROVED:

Dr. Christine T. Altendorf
Chief, Environmental Division
Directorate of Military Programs

9.6.12
Date

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2.0 DECISION SUMMARY

This section provides an overview of the site characteristics, alternatives evaluated, and an analysis of those alternatives. It also identifies the selected remedy and explains how the remedy fulfills statutory and regulatory requirements.

2.1 Site Name, Location, and Brief Description

Site Name:	Former Schilling Atlas F Missile Site S-5
Location:	McPherson County, Kansas
FUDS Project Number:	B07KS026301
Lead Agency:	U.S. Army Corps of Engineers, Kansas City District
State Support Agency:	Kansas Department of Health and Environment
Federal Support Agency:	U.S. Environmental Protection Agency – Region 7
Site Type:	Former U.S. Department of Defense (DOD) Atlas F Missile Base with Contaminated Groundwater
Site Description:	The former Schilling Atlas F Missile Site S-5 is one of 12 Atlas "F" type intercontinental ballistic missile (ICBM) sites assigned to the former Schilling Air Force Base, Salina, Kansas. The Site is located in McPherson County; approximately 7 miles north of the City of McPherson, Kansas. The S-5 Site is situated on an upland ridge located approximately one mile east of the former McPherson Landfill and just south of Pueblo Road (Figure 1). The missile base property is privately owned and used as a primary residence. Adjacent properties are used for bird hunting, cattle grazing, and cropland.

2.2 Site History

The former missile base was an operational ICBM launch facility from 1961 to 1965. It was one of 12 Atlas "F" type ICBM sites assigned to the former Schilling Air Force Base, Salina, KS (USACE 2011).

The Atlas "F" missile facilities typically consisted of an approximately 10-acre fenced area containing an underground LCC and missile silo; aboveground maintenance, administration, and water treatment buildings; and two water supply wells. Due to insufficient groundwater resources at the former S-5 Site, water was piped from approximately 8 miles west of the former missile base (USACE 2006).
The missile silo is 187 feet deep and 69 feet in diameter, and constructed of reinforced concrete. The LCC is buried approximately 50 feet below ground surface (bgs) and is connected to the silo

by a corrugated steel tunnel. The silo doors and missile elevator were controlled by hydraulic systems (USACE 2011).

After the missile base was deactivated, it was conveyed several times to different entities and owners from 1967 through 2011. The Site was purchased by the current landowners in 2011 (USACE 2011).

2.3 Previous Investigation and Response Actions

Environmental investigation and restoration activities at the Site were initiated by USACE in 1988 and have continued to the present remedial action activities. A list of investigations at the Site is provided below:

- Confirmation Study of Former Atlas Missile Sites for Potential Toxic and Hazardous Wastes (USACE 1989);
- Initial Phase Remedial Investigation (RI) (USACE 1997);
- Silo Water Investigation (USACE 1999);
- Phase II RI (USACE 2000 and USACE 2003);
- Phase III RI (USACE 2006);
- Feasibility Study (FS) Report (USACE 2009);
- Groundwater Modeling (USACE 2010); and
- Green and Sustainable Remediation Analysis Report (USACE 2010).

Results of these investigations indicate that trichloroethene (TCE) is present in groundwater above remediation goals and has migrated approximately 1,800 feet downgradient of the missile silo complex area. TCE concentrations were detected in subsurface soils from an area located near the LCC. A brief summary of these investigations can be found in Section 1.3 of the Phase III RI (USACE 2006).

2.3.1 Bottled Water and Granular Activated Carbon Treatment Systems

The former landowner originally obtained all potable water from a water supply well located west-southwest of the silo (Figure 2). However, due to the discovery of TCE contamination in this domestic water supply well, a series of interim measures were performed by USACE at the Site in order to provide the landowners with potable drinking water. In 1991, USACE began providing bottled water to the landowner. In 1993, USACE installed a GAC water treatment system as an interim solution to treat the water supply well.

2.3.2 Alternate Water Supply

In 2001, a new rural water district was created by local citizens with service to area landowners. In the fall of 2003, USACE connected the residence to the Lindsborg Area Rural Water District and discontinued operation of the GAC water treatment system.

2.3.3 2007 Treatability Study Report

The 2007 Treatability Study evaluated the effectiveness of enhanced anaerobic bioremediation (EAB) and SVE at the Site (USACE 2007).

2.3.3.1 Enhanced Anaerobic Bioremediation Treatability Study

The EAB technology was evaluated for the delivery methods of bioremediation substrate into the formation, the estimated radius of influence (ROI) at an injection point, and the ability of the EAB substrate to affect contaminant levels and/or to impose anaerobic conditions in the formation. Direct push injections for the EAB portion of the Treatability Study were executed during July and August of 2006.

Post-injection performance monitoring of contaminant concentrations and aquifer characteristics was conducted for one year in 2007 by USACE. The EAB technology showed little success because of a small ROI. The small ROI was most likely due to the low permeability geology, the delivery methods (direct push), the injectant (a non-emulsified product), and the volume of injectant used. EAB is expected to be successful with alternate delivery methods, a different injectant (such as emulsified vegetable oil), and increasing the volume of injectant.

2.3.3.2 Soil Vapor Extraction Treatability Study

SVE technology was evaluated for its ability to minimize/reduce TCE leaching from soils to the groundwater. The SVE portion of the Treatability Study was executed from August to November of 2006. SVE was successfully pilot-tested, removing an estimated 5.8 pounds of TCE contamination in the unsaturated zone near the LCC entrance. The Treatability Study determined that SVE was applicable for the overall objectives of reducing concentrations of TCE in soil to minimize the potential impacts to groundwater.

2.4 Community Participation

The Final Proposed Plan for the Site was made available to the public on April 15, 2011 as an Administrative Record file. A copy of the Administrative Record file, which contains the Proposed Plan and its supporting documentation [RI Reports (USACE 1997, USACE 2000, USACE 2003, and USACE 2006), FS Report (USACE 2009) and other related reports], is available at the following location:

Miller Library
McPherson College
1600 East Euclid
McPherson, KS 67460

The notice of availability of the Proposed Plan and date of the public meeting were published on April 7, 2011 in the McPherson Sentinel and the Lindsborg News Record. The public comment period was held from April 15, 2011 to May 16, 2011. A public meeting was held on April 26, 2011, at the Miller Library, McPherson College. The public was encouraged to participate in the decision making process by providing comments on the Proposed Plan and attending the public meeting. A total of seven questions were recorded during the public comment period. The questions and responses are provided in Section 3.1.

2.5 Site Characteristics

2.5.1 Geology and Hydrogeology

The Site is located where the McPherson Lowland physiographic province merges with the Smoky Hills physiographic province. The ground surface consists of a thin layer of loess, wind-blown sediment. The loess is underlain by the McPherson Formation, which consists of Pleistocene fluvial and slope deposits of silt, clay, sand, and gravel. The overburden soils at the Site, which extend to approximately 90 feet bgs, are silty clay to clay with discontinuous lenses of very fine to fine-grained sand and clay, and thin stringers of caliche (USACE 2011). Surface water drainage is radial, and flows away from the site in all directions except to the east and southeast. Surface water runoff flows into two ephemeral streams located 400 feet north of the silo and 1,200 feet west of the site. The ephemeral streams flow north-northwest and eventually discharge into Indian Creek (USACE 2006).

The main water-bearing zone at the Site is a 20 to 30-foot thick silty-clay to clay layer with discontinuous lenses of very fine to fine-grained sand and clay and thin stringers of caliche. This zone is located approximately 40 to 60 bgs in the vicinity of the silo, and is thought to be part of the McPherson Formation. Boring logs indicate that a sandy silty clay zone with up to 30% fine sand predominates the aquifer on the eastern half of the Site. The aquifer on the western half of the Site is predominated by caliche zones. Groundwater flow direction on the eastern portion of the Site is to the west-northwest, and is related to the Site's topography. On the very western edge of the Site, the flow direction is northerly, most likely related to the regional flow direction toward the Smoky Hill River. Groundwater discharges into the Smoky Hill River approximately 4 miles north of the Site. The Kiowa Shale bedrock beneath the Site is encountered generally between 80 and 100 feet bgs.

2.5.2 Nature and Extent of Contamination

The COCs in groundwater are TCE and its degradation product *cis*-1,2-dichloroethene (*cis*-1,2-DCE). Other degradation products of TCE were not detected at the site. Soil sampling during the RI indicated that TCE entered the soil near the LCC and migrated downward to groundwater. Contaminants are migrating with the groundwater flow.

TCE is present in groundwater at concentrations up to approximately 3,740 μg/L in groundwater monitoring well (GMW)-803. The extent of TCE contamination above 5 μg/L in groundwater is shown in Figure 2. The TCE contaminant plume extends approximately 1,800 feet from the missile base.

2.5.3 Conceptual Site Model

A conceptual site model was developed for the Site as shown in Figure 3. The conceptual site model was used to evaluate the potential pathways from human exposure to contaminants. The conceptual site model depicts contaminant sources, pathways, exposure routes, and possible current and future receptors.

2.6 Current and Future Land and Groundwater Use

2.6.1 Current and Future Missile Base Property Use

The missile base property is privately owned and serves as a primary residence. Figure 2 shows the current property with the former missile base site features.

2.6.2 Current and Future Surrounding Land Use

The property west and south of the missile base is utilized as a controlled game area from September through April and for agricultural purposes throughout the year. The properties to the north and east of the missile base are used for agricultural purposes. Figure 1 shows the proximity of the surrounding areas to the Site.

2.6.3 Current and Future Groundwater Use

Groundwater at the Site is currently not used for drinking water. In 2001, a local citizen group formed a new rural water district, headquartered in Lindsborg, Kansas, to provide water services to area residents. In the fall of 2003, USACE connected the residence to the Lindsborg Area Rural Water District system.

It is anticipated that in the future, the groundwater will not be used as a source for potable drinking water and its use as non-potable water will be limited.

2.7 Summary of Site Risks

A Baseline Risk Assessment was completed to evaluate potential risk to human health and the environment as part of the 2006 Phase III RI Report. The following sections summarize the site risks as presented in the 2006 Phase III RI Report (USACE 2006).

2.7.1 Human Health

For subsurface soil, a future construction worker scenario was evaluated assuming potential exposure through ingestion, dermal contact, and inhalation of dust and vapors. The estimated individual lifetime cancer risk for all pathways combined was $6x10^{-9}$, which is below the United States Environmental Protection Agency (USEPA) acceptable range of one in ten thousand to one in a million (expressed exponentially as $1x10^{-4}$ to $1x10^{-6}$). The total non-cancer hazard index (HI) was 0.0001. This estimate is well below 1, the level at which there is possible concern for non-cancer health risks.

Groundwater at the site is no longer used for household purposes by the current landowner, therefore, the exposure to groundwater is eliminated. However, a residential scenario assuming the possibility of future groundwater use was evaluated. Exposure pathways included tap water ingestion, dermal contact while showering, inhalation of vapors while showering, and inhalation of vapors that could migrate upward from groundwater and enter a building. The total individual lifetime cancer risk estimated for all pathways was $9x10^{-4}$, which exceeds the upper bound of the USEPA acceptable risk range of $1x10^{-4}$ to $1x10^{-6}$. TCE posed the greatest potential cancer risk based on an assessment with California Environmental Protection Agency toxicity values. The two pathways posing similarly significant cancer risk were tap water ingestion and inhalation of vapors while showering. The total non-cancer HI for a future resident was 6.3 (customarily rounded to 6), which exceeds the USEPA acceptable level of 1. The non-cancer HIs for TCE and *cis*-1,2-DCE were 3.7 and 2.6, respectively. The pathway posing the greatest non-cancer risk was inhalation of vapors while showering.

2.7.2 Ecological

A screening level ecological risk assessment was conducted. The ecological risk assessment evaluation found no completed exposure pathways to groundwater, soil (because of the depth to contamination), or surface water. The only potentially completed exposure pathway was from potential contact with sediment in either the ephemeral streams or in the sump discharge drainage ditch. The ecological field survey indicated that the site is a functioning ecological environment with no readily discernible negative effects. In addition, no endangered species were noted within the area. It was concluded that the site posed no significant risk to any ecological receptors.

2.8 Remedial Action Objectives

Groundwater remediation will mitigate future potential risks to residents. The following remedial action objective (RAO) for groundwater is:

- Prevent unacceptable risk to human health from potable use of groundwater containing COCs above RGs.

Groundwater remediation goals were developed based on an evaluation of Applicable or Relevant and Appropriate Requirements (ARARs), which can be found in the 2009 FS (USACE 2009). The groundwater cleanup criteria, or RGs, are equal to the MCLs for the COCs present at the Site, which are as follows:

- TCE – 5 μg/L
- *cis*-1,2-DCE – 70 μg/L

Based on the risk assessment, there is no direct exposure risk from soil at the site, thus, there is not a direct RAO for soil.

2.9 Description of Remedial Alternatives

Remedial alternatives considered for this site are presented in this section based on the results of a FS completed in 2009 (USACE 2009). Five groundwater remedial alternatives including four remedial soil measures were evaluated in the FS.

2.9.1 Groundwater Remedial Alternatives

Five groundwater remedial alternatives were developed and evaluated against the nine NCP criteria in the 2009 FS (USACE 2009). Note, that in the Proposed Plan (USACE 2011) and as presented here, given their similar attributes, the EAB and ISCO alternatives from the FS are combined into one In-Situ Treatment alternative for the purpose of the CERCLA criteria evaluation.

Alternatives 2, 3, and 4 include provision of an alternate water supply to future residences in the area whose potable water supply exceeds MCLs for COCs related to the Site.

2.9.1.1 Alternative 1: No Further Action

Under this alternative, no action would be taken at the Site to decrease contaminant concentrations and prevent exposure to groundwater contamination. However, well abandonment of groundwater monitoring and SVE wells would be conducted. The remediation timeframe (i.e. when RAOs are met in the groundwater plume) estimated from groundwater modeling is approximately 206 years (USACE 2011). The total present worth of this alternative is estimated at $25,700.

2.9.1.2 Alternative 2: Long-Term Monitoring/Monitored Natural Attenuation

Long-term monitoring/MNA (LTM/MNA) involves establishing a regular, periodic sampling and analysis program utilizing the existing monitoring well network at the Site to monitor the migration and attenuation of the TCE plume. Dilution and dispersion are the primary attenuation pathways at this Site. The specific monitoring network, frequency of sampling, and criteria for terminating sampling of individual monitoring wells that have reached RGs will be developed during the remedial design or remedial action phase. Five-Year Reviews will be required until groundwater monitoring results indicate that concentrations have met the RGs. Groundwater modeling has shown that the remediation timeframe for this alternative is approximately 206 years (USACE 2011). The total present worth of this alternative is estimated at $879,300 for a 30-year costing period.

2.9.1.3 Alternative 3: In-Situ Treatment with Monitored Natural Attenuation

This alternative would involve full-scale implementation of either EAB, pilot-tested in the 2007 Treatability Study, or ISCO injections into the contaminant plume. In-situ treatment with EAB involves injection of a bioremediation substrate, such as emulsified vegetable oil, lactate, or other substrate, which would provide an electron donor supply for enhancing biological reductive dechlorination. In-situ treatment with ISCO involves injection of a chemical oxidant to contact and chemically convert contamination to nonhazardous or less toxic compounds that are more stable, less mobile, or inert.

The In-Situ Treatment using EAB or ISCO would be applied to a portion of the plume determined during the remedial design. The specific injectant that will be used for the In-Situ Treatment will also be determined during remedial design. The various EAB substrates and ISCO oxidant will be evaluated and selected based on the most effective material under the site specific conditions at the time of remediation in the target treatment area.

Following injections, contaminant concentrations would be monitored for reduction of COC concentrations. MNA would be utilized to monitor the effectiveness of the remediation and degradation of the site specific COCs. The remedial design will describe the groundwater monitoring program including performance goals, monitoring strategy, and the appropriate response actions should the performance goals not be achieved. Remedy effectiveness would be demonstrated when RGs are met at compliance wells designated in the remedial design.

Five-Year Reviews will be conducted until RGs have been achieved at compliance wells designated in the remedial design. Groundwater modeling has shown that the remediation timeframe for this alternative is approximately 78 years after injections are completed. The total present worth of this alternative is $7,521,500 over a 30-year period.

2.9.1.4 Alternative 4: Permeable Reactive Barrier or a Biowall with Monitored Natural Attenuation

This remedial alternative involves installing a permeable reactive barrier (PRB) or biowall downgradient from the treatment area to intercept and remediate the higher concentration areas of the plume. The PRB/biowall would contain a bioremediation substrate such as mulch or a chemically reactive medium such as zero-valent iron (ZVI) that would treat the intercepted contaminant plume either by reductive dechlorination or adsorption onto the media.

Performance monitoring wells would be installed at locations upgradient, within, and downgradient of the PRBs/biowalls to measure the performance of the remedy and to determine whether recharge of the treatment media is needed. PRBs would be expected to last 10–30 years before reactivity or hydraulic issues would result in the need for maintenance. At that point, the PRB media could be recharged, either by physically replacing the media, or by injection of a bioremediation substrate and/or ZVI. The biowall media could require replacing after approximately 7 to 10 years, though this may be conservative and the media could actually last twice as long depending on site conditions.

Contaminant concentrations would be monitored for reduction of COC concentrations. MNA would be utilized to monitor the migration of the site specific COCs. The estimated remediation timeframe of 206 years is relatively long compared to the other alternatives due to the slow advection of groundwater at the site and the resulting timeframe for the entire contaminant plume to pass through the PRB. The remedial design will describe the specific groundwater monitoring program including performance goals and monitoring strategy.

Five-Year Reviews will be required until groundwater monitoring results indicate that concentrations have met the RGs. The total present worth of the PRB portion of the remedy is $11,630,200 (includes a 30-year costing period and costs to implement MNA), and the total present worth of the biowall portion of the remedy is $8,026,700 over a 30-year costing period (includes costs to implement MNA).

2.9.2 Soil Area Remedial Measures

There is no direct exposure risk from the soil at this site. Soil remediation measures are included as an overall approach to groundwater remediation. The soil area dimension is approximately 60 feet (length) by 50 feet (width) by 25 feet (depth). The FS evaluated the remedial soil measures in the soil area to complement the groundwater remedial alternatives (USACE 2009).

The following sections briefly describe the remedial soil measures presented in the FS and summarize their effectiveness in meeting the objectives of decreasing contaminant concentrations in soil and remediation timeframe.

2.9.2.1 No Further Action – Soil Area

No actions would be taken at the Site to decrease soil/vadose zone contaminant concentrations. Abandonment of the existing SVE wells would be included in this alternative. The total present worth of this remedial measure is estimated at $10,400.

2.9.2.2 Soil Vapor Extraction – Soil Area

SVE is a process by which a pressure gradient or vacuum is applied to the unsaturated zone for the purpose of removing VOCs within the ROI of the SVE well. The induced flow of air through the soil matrix removes VOCs from the soil. SVE involves a full-scale implementation of the SVE portion of the 2007 Treatability Study. The SVE system would operate until VOCs in soils reach an asymptotic level (i.e., when no appreciable amount of contamination can be removed), or a maximum of 2 years. The goal is to remove mass to decrease the overall remediation timeframe. It is expected that asymptotic levels would be achieved in less than one year. The total present worth of this remedial measure is estimated at $511,700.

2.9.2.3 Excavation – Soil Area

Contaminated soil near the LCC entrance would be excavated and transported to a permitted off-site treatment and/or a disposal facility. Heavy construction equipment would be used to excavate, stockpile, load, and transport the area soil. The depth of the excavation is set at 25 feet bgs, which would remove the most highly contaminated soil areas as identified in the RI Report. This soil remedial measure would be a permanent solution to reduce contaminants. The total present worth of this remedial measure is estimated at $739,900.

2.9.2.4 In-Situ Chemical Oxidation Treatment – Soil Area

In-situ chemical oxidation (ISCO) treatment involves injection of chemical oxidant into the contaminated soils in the unsaturated zone near the LCC entrance in order to chemically oxidize COCs into non-toxic chemicals. ISCO treatment in the soil would permanently destroy contamination if the injected oxidant is effective in contacting the contaminants. The depth of the ISCO treatment is set at 25 feet bgs, which would remove the most highly contaminated soil areas as identified in the RI Report.

Close injection spacing and large quantities of oxidant could be required to achieve complete oxidation of contaminants.

The total present worth of this remedial measure is estimated at $780,600.

2.9.2.5 Summary of Remedial Soil Measures

SVE was the remedial soil measure that demonstrated effectiveness in decreasing contaminant mass in the soil soil area during the pilot study. Costs for the SVE remedial soil measure were combined with the Groundwater Remedial Alternatives 2, 3, and 4 in Section 2.9.1 for the total present worth remediation cost.

2.10 Summary of Comparative Analysis of Alternatives

The USEPA has developed nine criteria that balance health, technical, and cost considerations to determine the most appropriate remedial alternative. These criteria are used in the decision making process to select a remedial action that is protective of human health and the environment, attains ARARs, and is cost effective. The four groundwater remedial alternatives described in Section 2.9.1 have been evaluated and compared using the nine criteria set forth under the NCP. These nine criteria are summarized below:

1. Overall Protection of Human Health – Overall protection of human health and the environment addresses whether or not a remedy provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. Compliance with ARARs – Compliance with ARARs addresses whether or not a remedy will meet all of the ARARs of other federal and state environmental statutes and requirements, or provides grounds for invoking a waiver.

3. Long-Term Effectiveness and Permanence – Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met.

4. Reduction of Toxicity, Mobility, or Volume – Reduction of toxicity, mobility, or volume through treatment is the anticipated ability of the treatment to reduce the toxicity, mobility, or volume of the waste and, if possible, to what extent.

5. Short-Term Effectiveness – Short-term effectiveness addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. Implementability – Implementability is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. Cost – Cost includes estimated capital and operation, maintenance costs, and net present worth costs.

8. State Acceptance – State acceptance is the evaluation of the technical and administrative issues and concerns the state may have regarding each of the alternatives.

9. Community Acceptance – Community acceptance is based on the evaluation of public comments received on the Proposed Plan.

The first two criteria are considered threshold criteria and each alternative must meet these criteria to receive further consideration. The next five criteria represent the Primary Balancing Criteria on which the alternative analysis is based. The final two criteria are the Modifying Criteria and include State Acceptance and Community Acceptance. Modifying criteria were evaluated following the public comment period.

2.10.1 Overall Protection of Human Health

Remedial Alternatives 2 through 4 are all protective of human health and the environment, because exposure risk has been eliminated by providing an alternate water supply to all impacted area residences. Alternatives 2 through 4 use monitoring as a way to measure the performance of the alternative and to monitor the contaminant plume. Alternative 1 (No Action) is not protective of human health and the environment as it assumes no future actions, including no action, to protect future residences impacted by COCs above MCLs.

2.10.2 Compliance with Applicable or Relevant and Appropriate Requirements

The No Action Alternative 1 does not comply with ARARs threshold criteria. Therefore, the No Action Alternative was not evaluated further for primary balancing criteria. Alternatives 2 through 4 comply with the ARARs.

2.10.3 Long-term Effectiveness and Permanence

Alternative 2 (LTM/MNA) relies on natural attenuation, which at present occurs at a very slow rate and predominantly works through dispersion and dilution mechanisms. Groundwater modeling has estimated that the remedial timeframe of this alternative will be approximately 206 years (USACE 2011).

Alternative 3 (In-Situ Treatment with MNA) depends on the ability to deliver an EAB or ISCO injectant into the aquifer. Once in the aquifer, some EAB substrates could be effective up to one year before a reinjection of substrate would be needed. For ISCO, there are chemical oxidation products that could be effective up to six months before a reinjection is needed. Alternative 3 is more aggressive than the other alternatives, and would likely remove more contamination faster than the other alternatives if the bioremediation substrate or oxidizing chemicals are distributed effectively in the aquifer. Groundwater modeling has estimated that the remedial timeframe of this alternative will be approximately 78 years (USACE 2011).

The structure of a PRB in Alternative 4 is permanently set in the ground and designed to intercept and remediate the contaminant plume. However, the PRB/biowall media usually needs recharging. The FS Report conservatively estimated recharge to occur every 10 years for a PRB and every 7 years for a biowall (USACE 2009). However, the PRB or biowall media could actually last double these numbers depending on site conditions.

2.10.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 2 through 4 provide a reduction in mobility and a reduction in toxicity and volume by their ability to achieve RGs over time.

Alternative 3 (In-Situ Treatment with MNA) would be the most aggressive of the alternatives in reducing the amount of contamination at the Site, if the substrate or oxidant can effectively come in contact with contamination and create an environment to enhance contaminant degradation. However, the site geology poses problems with completing contact between the injectant and the contamination.

Alternative 4 (PRB with MNA) would effectively decrease contamination once it passes through the PRB; however, the slow advection of the groundwater would result in a slow remediation process of the contaminant plume.

2.10.5 Short-Term Effectiveness

Alternatives 2 through 4 would meet the criterion of short-term effectiveness since an alternate water supply will be provided to residences if their potable water supply becomes compromised by COCs above RGs, eliminating the direct exposure risk via ingestion and inhalation.

The risks of adverse effects to human health during the remedial phase are low for the implementation of LTM/MNA, SVE, and In- Situ Treatment in Alternatives 2 through 4.

2.10.6 Implementability

Alternative 2 (LTM/MNA) would require minimal effort to implement. Alternative 3 (In-Situ Treatment with MNA) depends on effective delivery and distribution into the aquifer. The 2007 Treatability Study demonstrated that direct push technology injections can be done, but with a small ROI due to the very stiff soil and slow advection of groundwater at the Site. Alternative 4 (PRB or biowall with MNA) would take more effort to implement, as heavy earth moving equipment would be used for installing the PRB or biowall.

2.10.7 Cost

The estimated total costs and present worth costs of the alternatives were developed in the FS Report (USACE 2009) and are summarized in Table 1. In order to estimate the total remediation costs, combine the cost for SVE with the estimated total cost for Alternatives 2, 3, or 4.

For Alternative 2, the total estimated cost is for 30 years of groundwater monitoring. However, since natural attenuation conditions at the site are not very conducive to reductive dechlorination, it is likely that the site will need monitoring for a much longer period before groundwater RGs are reached, which is estimated at approximately 206 years.

For Alternative 3, the total estimated cost is based on an initial injection of substrate or oxidant into the contaminant plume, followed by annual re-injections for the next three years, and thirty years of MNA sampling. Multiple injections may be considered to expedite the remediation timeframe. The actual number of injections and amount of sampling will depend on effectiveness of each injection as defined in the remedial design. Assumptions on number of injections are for cost purposes only. It is estimated that the groundwater RGs will be reached in approximately 78 years.

For Alternative 4, the total estimated cost is based on installation of either a PRB or biowall that intersects the contaminant plume and 30 years of MNA sampling to monitor the effectiveness of the PRB or biowall. The estimate accounts for periodic recharging of the media (conservatively estimated at 10 years for a PRB, 7 years for a biowall) to ensure continued remediation of the contaminant plume. It is estimated that the groundwater RGs would be reached in 206 years.

Table 1. Summary of FS Report (30-year) Remedial Alternative Cost Estimates

Remedial Alternative	Estimated Total Cost	Present Worth Cost
Groundwater Alternative 1 – No Action	$25,700	$25,700
Groundwater Alternative 2 – LTM/MNA	$1,176,700	$879,300
Groundwater Alternative 3 – In-Situ Treatment with MNA	$8,448,400	$7,521,500
Groundwater Alternative 4 – PRB with MNA	$15,132,500	$11,630,200
Groundwater Alternative 4 – Biowall with MNA	$10,704,700	$8,026,700
SVE Soil Area Measure	$514,500	$511,700

2.10.8 State Acceptance

The State of Kansas provided a letter dated February 22, 2012 that indicated concurrence with selection of Alternative 3, In-Situ Treatment and SVE with MNA, as the site remedy.

2.10.9 Community Acceptance

A total of seven questions were received during the public comment period (April 15, 2011 to May 16, 2011). Individual questions and responses are discussed in Section 3.1.

2.11 Consideration of Green and Sustainable Remediation Practices

The 2009 DOD Memorandum "Consideration of Green and Sustainable Remediation Practices in the Defense Environmental Restoration Program" (DOD 2009) directs, "when and where it makes sense," the use of GSR strategies for remedial actions that:

- Use natural resources and energy efficiently;
- Reduce negative impacts on the environment;
- Minimize or eliminate pollution at its source;
- Protect and benefit the community at large; and
- Reduce waste to the greatest extent possible.

The 2010 Green and Sustainable Remediation (GSR) Analysis Report (USACE 2010), which is included in the Administrative Record File, was performed to compare the In-Situ Treatment with MNA alternative to the LTM/MNA alternative. The results of the GSR evaluation indicate that the LTM/MNA alternative is generally less sustainable than the In-Situ Treatment with MNA alternative.

For example, the LTM/MNA alternative is calculated to have approximately 60-100% higher greenhouse gas emissions, energy use, and worker accident/fatality risk as well as 30-55% priority criteria pollutant emissions. The higher emissions, energy usage, and accident/fatality risk are largely due to the more extended monitoring period (206 years vs. 78 years) of the LTM/MNA alternative. Only the water use for the LTM/MNA alternative is calculated to be lower (~70%), which is due to the larger amounts of water necessary with the In-Situ Treatment alternative for dilution and injection of substrate or oxidant.

2.12 Selected Final Remedy

Alternative 3, In-Situ Treatment of groundwater followed by MNA monitoring is the selected remedy for the Site. Additionally, SVE for soils has been incorporated into the remedy to minimize the potential for impacts to groundwater. KDHE has indicated support for this alternative.

2.12.1 Summary of Rationale for Selected Remedy

Alternative 3 met the threshold criteria and provides an appropriate balance among the Balancing and Modifying Criteria. Additionally, the preferred alternative satisfies the requirements of CERCLA: (1) protective of human health and the environment; (2) comply with ARARs; (3) cost-effective; (4) use permanent solutions and alternative treatment technologies and resource recovery technologies to the maximum extent practicable; and (5) satisfy the preference for treatment as a principal element.

2.12.2 Description of Selected Remedy

The selected remedy addresses groundwater contamination using an in-situ treatment technology, SVE for soils incorporated into the remedy to minimize impacts to groundwater, followed by MNA. The selected remedy will include providing an alternate water supply to residents if their drinking water supply becomes impacted by Site COCs above the RGs in the future.

Major components of the selected remedy include the following:

- In-situ treatment of groundwater to reduce contaminant concentrations in groundwater based on remedial design criteria focusing on areas of highest COC concentrations.
- Installation and operation of an SVE system in the soil area located near the LCC entrance on the missile base property.
- Installation of groundwater monitoring wells, sampling, and data analysis.

2.13 Statutory Determination

In accordance with statutory requirements of CERCLA, the remedial action shall be protective of human health, comply with ARARs, be cost effective, utilize permanent solutions and alternative treatment technologies to the maximum extent practicable, and prefer treatment as a principal element.

2.13.1 Protection of Human Health and the Environment

The remedy will be protective by implementing in-situ treatment of groundwater with EAB or ISCO to reduce COC concentrations, SVE of area soils to reduce contaminant mass, and MNA monitoring until RGs are achieved. An alternate water supply will be provided to residents if their potable water supply is impacted by COCs above RGs.

2.13.2 Compliance with Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with ARARs. Final remediation goals for groundwater are presented in Table 2.

Table 2 Groundwater Remediation Goals

COC	Final Remediation Goal	Basis of Final Remediation Goal	ARAR
TCE	5 µg/L	MCL – 40CFR141	40 U.S.C 300 et seq.
cis-1,2-DCE	70 µg/L	MCL – 40CFR141	40 U.S.C 300 et seq.

2.13.3 Cost Effectiveness

The selected remedy is considered cost effective because it provides long-term effectiveness and permanence at a reasonable cost as compared to other alternatives. The estimated costs presented in Table 1 represent the costs developed for the FS Report, which considered a remediation timeframe of 30 years.

2.13.4 Permanent Solution and Alternate Technology

The selected remedy provides a permanent solution for remediation using proven In-Situ Treatment and SVE technologies to reduce contaminant mass in the groundwater and soil.

2.13.5 Preference for Treatment as a Principle Element

The selected remedy includes treatment as a principal component. In-Situ treatment will be used to actively treat the groundwater, followed by MNA, and SVE of soils will compliment the groundwater remedy by removing contaminant mass.

2.13.6 Five-Year Reviews

Five-year reviews are required to ensure that the selected remedy is protective of human health and the environment and the remedy is meeting RAOs. Five-year reviews will be conducted until groundwater compliance wells designated in the remedial design achieve RGs.

2.13.7 Significant Changes

The Proposed Plan was released for a public comment from April 15, 2011 to May 16, 2011 with a public meeting held on April 26, 2011. The Proposed Plan identified Alternative 3 as the Preferred Alternative for remediation. A total of seven questions were received during the public comment period. No significant changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate.

3.0 RESPONSIVENESS SUMMARY

This Responsiveness Summary provides responses from USACE to comments received during the public comment period for the Proposed Plan. The public comment period for the Proposed Plan was from April 15, 2011 to May 16, 2011. USACE sponsored a public meeting at the Miller Library, McPherson College on April 26, 2011.

3.1 Summary of Comments and Responses

A total of seven questions were received during the public comment period. The individual comments as well as USACE's responses are shown below.

1. What will be the monitoring frequency for the future monitoring activities at this site?

   Response: The remedial design will describe the specific groundwater monitoring program including frequency of future monitoring at the site.

2. How deep is the plume of contaminated groundwater? What are the chances of it escaping and causing problems to people or animals on the surface?

   Response: The groundwater contamination is encountered at about 40 feet below the ground surface. Groundwater contamination is not expected to migrate to other known residential water supply wells in the future. Additionally, the selected remedial alternative includes the provision for an alternate water supply to area residents whose potable water supply exceeds RGs for the contaminants of concern (COCs).

3. Are there any drinking water sources that are at risk?

   Response: The residential potable water supply well nearest to the site is approximately 1 mile upgradient of the site, in the opposite direction of groundwater flow, and is unlikely to become affected. Residents whose potable water supply exceeded RGs for the contaminants of concern were connected to the rural water district as an alternate permanent water supply. The selected remedial alternative includes the provision for an alternate water supply to area residents whose potable water supply exceeds RGs for the COCs, although other area residents are not expected to be affected.

4. What are the criteria for deciding to let the plume naturally attenuate? Will that be when the contamination has been reduced to five parts per billion?

   Response: Following in-situ treatment injections, contaminant concentrations will be monitored for reduction of COC concentrations. MNA will be utilized to monitor the groundwater degradation. The remedial design will describe the specific groundwater monitoring program. Five-Year Reviews will be required until groundwater monitoring wells designated in the remedial design achieve remediation goals.

5. If for some reason this plume starts moving again, are you confident that your monitoring wells will detect that? Will you need more monitoring wells? Will these monitoring wells be core sampled or just drilled?

   Response: As part of the MNA monitoring, a review of the network of existing monitoring wells will be conducted and where necessary, additional monitoring wells will be installed. The wells will be sampled according to the groundwater monitoring program plan until RGs are achieved. The type of drilling for installation of additional monitoring wells, if needed, will be dependent on the proximity to existing subsurface geologic information.

6. The owners of the area around the missile site have children, horses and animals. Is there any contamination which would be harmful to people, plants or animals?

   Response: The Baseline Risk Assessment identified TCE contamination of the groundwater posed the greatest potential cancer risk through ingestion or through inhalation of volatilized TCE from shower water. Thus, the use of groundwater via untreated wells as potable water is not advisable and was discontinued at the site.

7. The TCE is in the soil and dry part still and is leaching downward, it is not percolating upward? If so, are there any concerns about walking around in that area or having horses in the area?

   Response: Precipitation to the ground surface causes residual TCE in the soil to migrate downwards. The Baseline Risk Assessment concluded that there is no direct exposure risk from the soil at this site.

4.0 REFERENCES

DOD 2009. *Memorandum "Consideration of Green and Sustainable Remediation Practices in the Defense Environmental Restoration Program".*

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USACE 1997. *Initial Phase Remedial Investigation Report, Former Schilling Atlas Missile Site S-5, McPherson County, Kansas.* Conducted by AmTech Engineering, Inc., Indianapolis, IN for USACE.

USACE 2000. *Draft Final Phase II Remedial Investigation Report, Former Schilling Atlas Missile Site S-5, McPherson County, Kansas.* Conducted by AmTech, Inc, Indianapolis, IN for USACE.

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USACE 2006. *Final Phase III Remedial Investigation Report Addendum Former Schilling Atlas Missile Site S-5 at McPherson, Kansas.*

USACE 2007. *Treatability Study Report for the Former Schilling Atlas Missile Site S-5 at McPherson, Kansas.* Conducted by Burns & McDonnell and Environment Chemical Corporation for USACE.

USACE 2009. *Final Feasibility Study Former Schilling Atlas Missile Site S-5 at McPherson, Kansas.*

USACE 2010. *Final Green and Sustainable Remediation (GSR) Analysis Report, Former Schilling Atlas Missile Site S-5, McPherson County, Kansas.*

USACE 2011. *Final Proposed Plan Former Schilling Atlas Missile Site S-5 at McPherson, Kansas.*

USEPA 1990. *National Oil and Hazardous Substances Pollution and Contingency Plan, Final Rule.* (40 CFR Part 300), Federal Register 55(46):8666-8865.

Zheng, C. and Bennett, G. D. 2002. *Applied Contaminant Transport Modeling.* John Wiley and Sons Inc., New York.

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FIGURES

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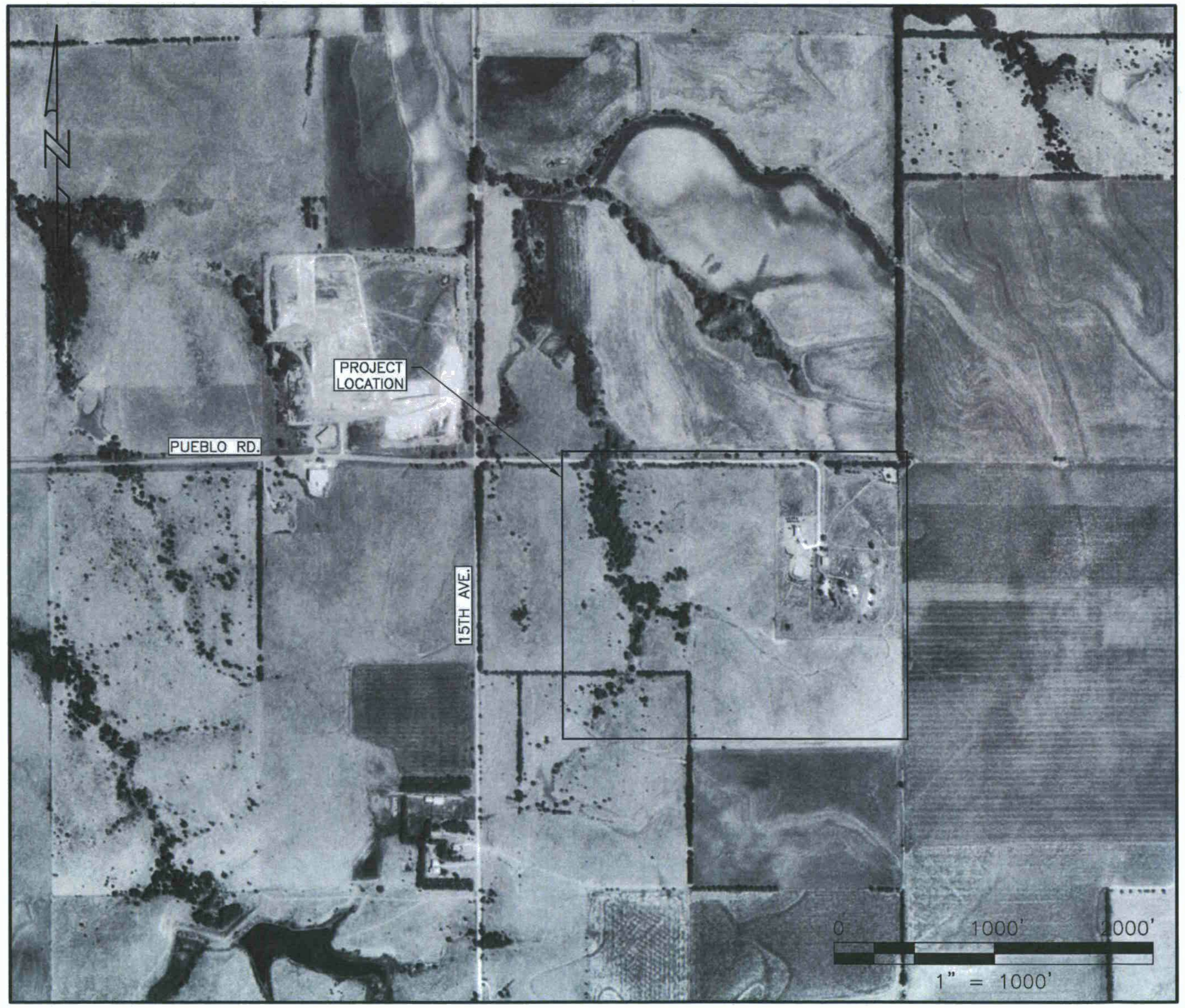
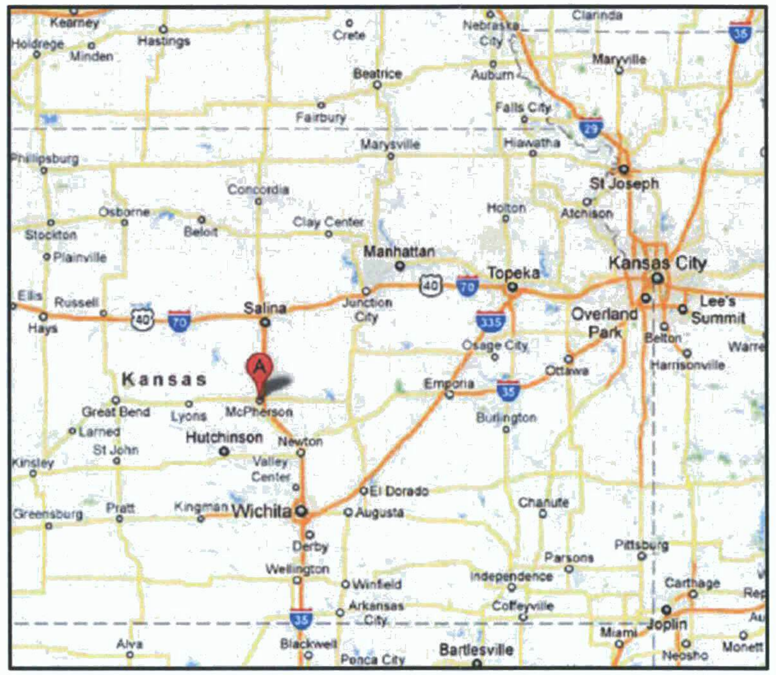
FORMER SCHILLING ATLAS MISSILE SITE
MCPHERSON, KANSAS
FUDS PROJECT NO. B07KS026301



SITE VICINITY MAP



SITE LOCATION MAP

US Army Corps of Engineers ®
Kansas City District

FORMER SCHILLING ATLAS MISSILE SITE S-5
MCPHERSON, KANSAS

FIGURE 1

SITE VICINITY AND LOCATION MAPS

DATE:	PROJECT:	REVISION:
JAN. 13, 2012	11135	0

Save Date: 2/3/2012 9:23 AM Plot Date: 2/3/2012 9:26 AM
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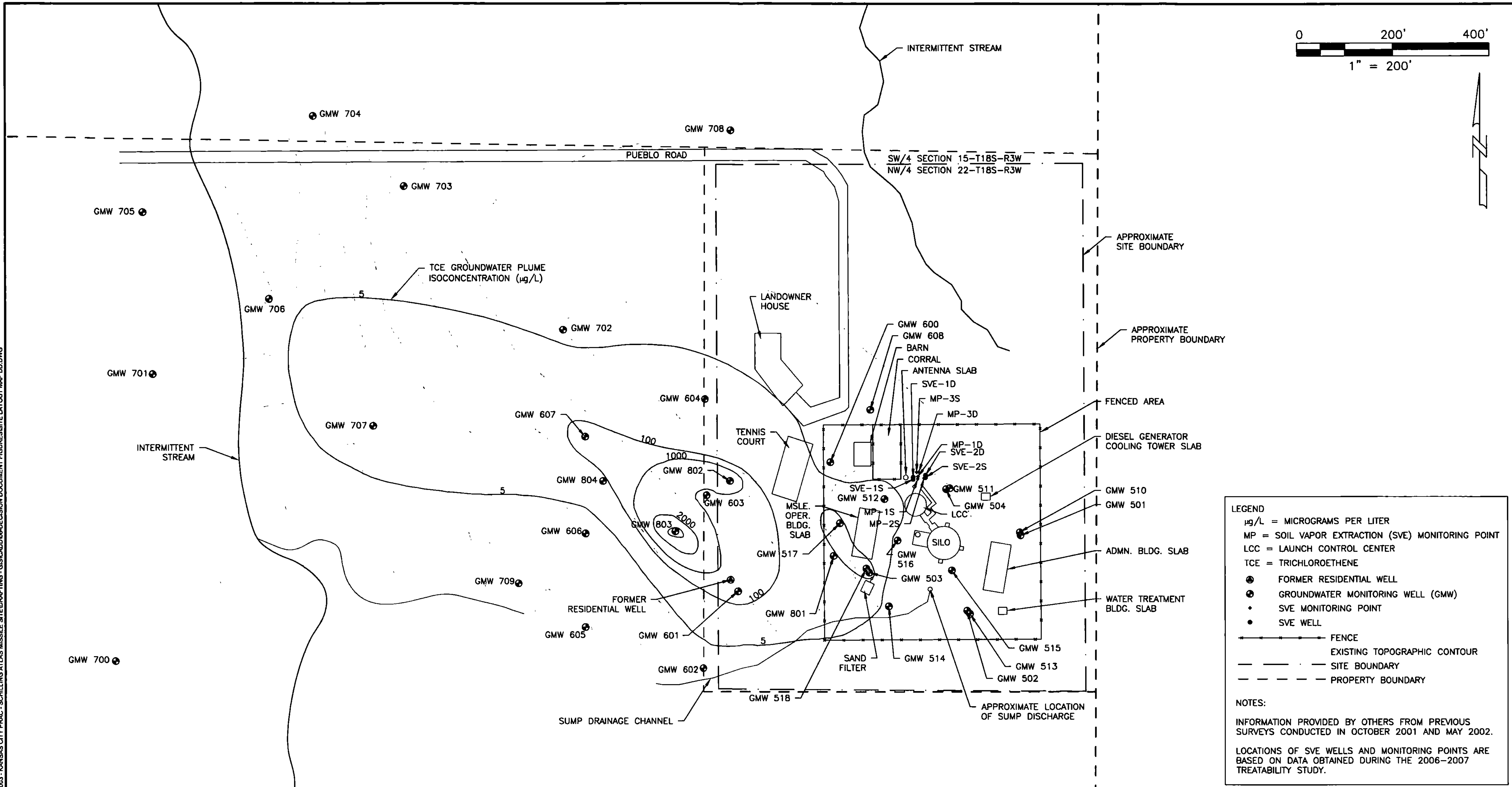


US Army Corps of Engineers ®
Kansas City District

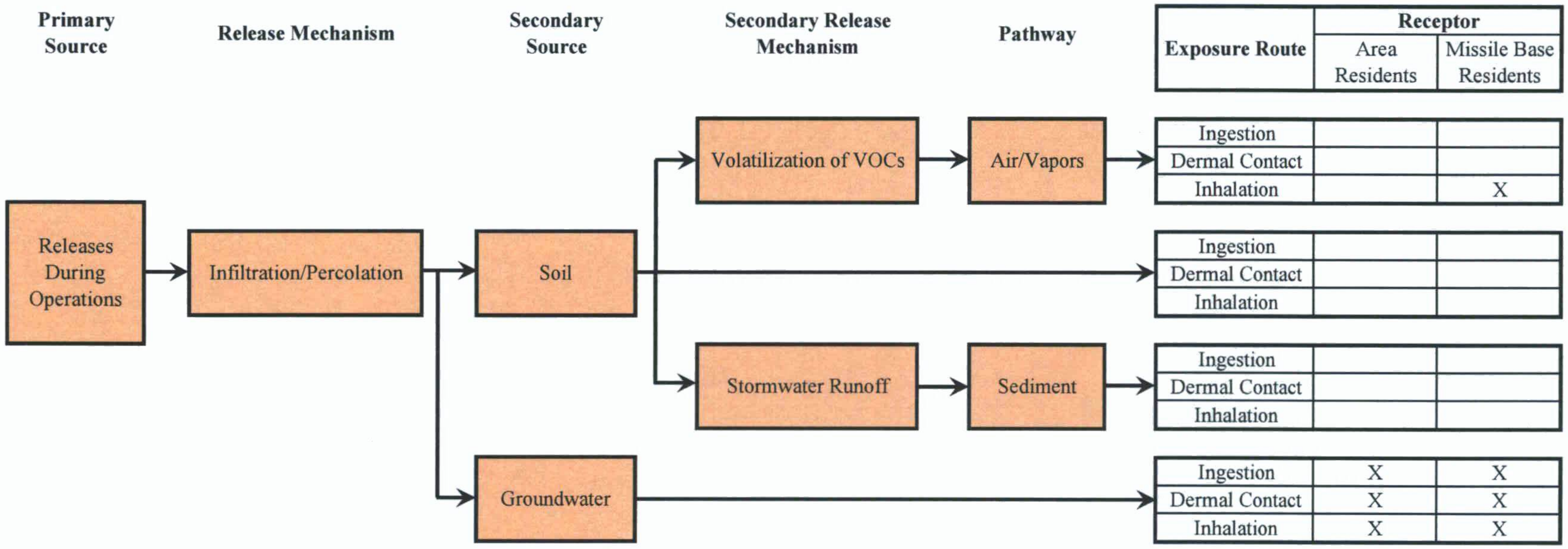
FORMER SCHILLING ATLAS MISSILE SITE S-5
MCPHERSON, KANSAS

FIGURE 2

SITE LAYOUT MAP

DATE: JAN. 13, 2012	PROJECT: 11135	REVISION: 0

Conceptual Site Model of the Former Schilling Atlas Missile Site S-5



Notes:

Empty receptor box denotes incomplete pathway, no evaluation required.

"X" in receptor box denotes pathway is or might be complete.